

UC Berkeley

Berkeley Scientific Journal

Title

The Positives of Parasitism: An Investigation into Cancer-Combatting Parasites

Permalink

<https://escholarship.org/uc/item/86z0s1n9>

Journal

Berkeley Scientific Journal, 30(1)

ISSN

1097-0967

Author

Schwarz, Jamie

Publication Date

2026-10-30

DOI

10.5070/BS3.69968

Copyright Information

This work is made available under the terms of a Creative Commons Attribution-NonCommercial-NoDerivatives License, available at <https://creativecommons.org/licenses/by-nc-nd/4.0/>

THE POSITIVES OF PARASITISM: AN INVESTIGATION INTO CANCER-COMBATTING PARASITES

BY: JAMIE SCHWARZ

Parasitic Pros and Hygienic No's

The word parasite invariably elicits a negative reaction. Scientifically, a parasite is classified as an organism that receives food, shelter, and ideal breeding conditions at the direct or indirect harm of its host. This one-sided relationship has also taken on a meaning outside of human health, applied in a social context to describe someone exploiting others

while providing little in return.¹ In popular culture, parasitism is also associated with the chilling and death-filled Academy Award winner *Parasite* (2019). So, if a reputation of destruction seems to follow parasitic organisms within and beyond a scientific context, how are they now emerging as promising allies in the fight against cancer?

The idea for harnessing parasites to

combat cancer stems from the hygiene hypothesis, a popular theory that correlates the increasing prevalence of allergies and autoimmune diseases in developed countries with the decreasing rates of exposure to microorganisms (germs) during childhood.² This phenomenon is attributed to improved sanitation and hygiene levels within these developed societies that leads to less active and more vulnerable immune systems. Now, subsequent research has broadened the hypothesis to suggest that this lack of germ exposure may also contribute to cancer development. This connection can be explained by the fact that an active immune system is key for cancer defense—and increased germ exposure does just that. Hence, pathogens have become key players in cancer immunotherapy. Already, bacterial and viral vaccines have been implemented in cancer prevention regimens. For example, vaccines for human papilloma virus (HPV) and hepatitis B virus (HBV) are the biggest preventative interventions for reproductive and liver cancers, respectively.³ In contrast with therapeutic approaches to cancer treatment, preventative vaccines are more accessible and far less invasive in terms of changes to a patient's quality of life.

Beyond counteracting the hygiene

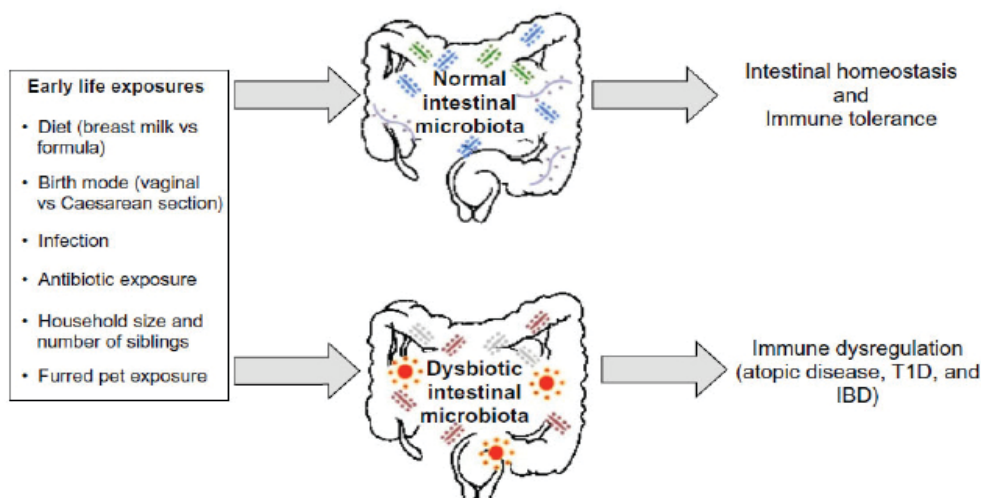


Figure 1: Early life exposure to microorganisms impacts immune stability (Hygiene Hypothesis). Early exposure to germs directly contributes to development of either normal or dysbiotic (imbalanced) gut bacteria, which then influences immune system development. For example, breast milk and vaginal births both confer immune cells and strength from mother to infant, a benefit lacking in formula and Caesarean sections.

hypothesis, treatments involving viral and bacterial proteins are favorable in cancer treatment due to their relatively high efficacy. A key survival mechanism of tumor cells is their ability to avoid immune control. This makes vaccines that target tumor cells directly inherently ineffective, as the tumor-associated antigens they carry are accepted into a patient's body as non-foreign, leading to a weak immune response.⁴ Pathogenic antigens, on the other hand, are far more effectively recognized as a danger. Thus, vaccines carrying viral and bacterial proteins trigger a stronger immune response with stronger cancer-fighting abilities.

Foundation of Research and Results

It is essential to note that human-infecting parasites include unicellular protozoa, and multicellular helminths (worms), all of which are eukaryotic organisms unlike bacteria and viruses. This evolutionary closeness to humans allows for complex gene regulation and unique interactions with the host immune system beyond the abilities of other pathogens. Taking this fact and the hygiene hypothesis into account, researchers have begun to investigate the immune-boosting effects of parasitic infection.

At a macroscopic level, this phenomenon has already been demonstrated. In fact, lower cancer prevalence is observed in patients with hydatid disease, a parasitic infection from a tapeworm called *Echinococcus granulosus*.⁵ In addition, studies have shown proof of a negative correlation between malaria infection and cancer death.⁶ There is even evidence of cancer patients' life spans improving when simultaneously infected with certain parasites.⁷ The cellular mechanisms for these observations is the focus of novel cancer research and will be explored in the rest of this article.

To understand how parasites might intervene in cancer progression, it is important to outline how cancer develops at a high level. First, a cancerous cell is characterized by uncontrolled cell division, which can lead to the development of a tumor, or abnormal tissue mass. To facilitate this rapid growth, cancerous cells promote angiogenesis, which is the branching of pre-existing blood vessels to increase the supply of nutrients to tumor cells to support faster rates of cell division.

The next stage of cancer progression is called metastasis, or the movement of cancer cells from their original location to other parts of the body, often through blood and lymphatic transport systems.⁸

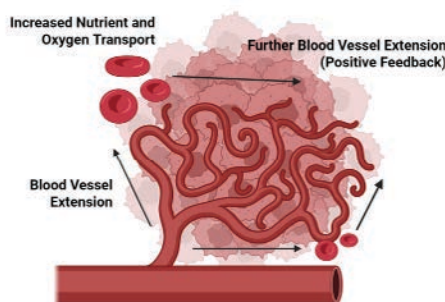


Figure 2: Tumor performing angiogenesis. Uncontrolled cell division creates a mass of cells, or tumor, that attaches to a pre-existing blood vessel, represented by the thick red tube at the bottom of the graphic. Once attached, the tumor promotes branching of the vessel to more efficiently transport nutrients and oxygen directly to the cancerous cells, facilitating even more rapid growth.

Anti-Cancer Mechanisms of Parasites Immunomodulation

In order to rapidly divide without inhibition, cancer cells create an immunosuppressed environment, a mechanism known as immunomodulation. One of the key anti-cancer abilities of a parasitic infection is the reclamation of this immune control. A parasite is a major foreign body, and its presence constantly alerts and stimulates the host immune system. Following parasitic infection, more immune cells are produced and activated from latency. In attempting to fight off the parasite, the body's immune system also recognizes and eliminates cancer cells—something that had not occurred in the previously immunosuppressed environment. Beyond this inherent immune system activation, parasites promote the expression of co-stimulatory molecules, which release inflammatory cytokines.³ Essentially, cytokines are a family of chemical messengers that tell the immune system when and where to respond. When more cytokines are released, there is a greater feedback boost in immune activity.⁹

Moreover, empirical data has shown that parasitic immune control involves apoptosis, or programmed cell death, of cancer cells and the suppression of tumor

growth factor.¹⁰ Remarkably, research has also seen great specificity in this apoptotic clearance, with a particular parasite called *T. cruzi* inducing cell death in cancerous melanoma cells and not in healthy melanocytes.¹¹ In comparison with current cancer treatments, like chemotherapy, that attack cells without distinction between healthy and cancerous, a parasitic alternative could be less invasive and harmful to a patient. Further experiments have found that hydatid cyst fluid also actively triggers tumor apoptosis, explaining the lower cancer prevalence found in hydatid-infected individuals as previously discussed.¹²

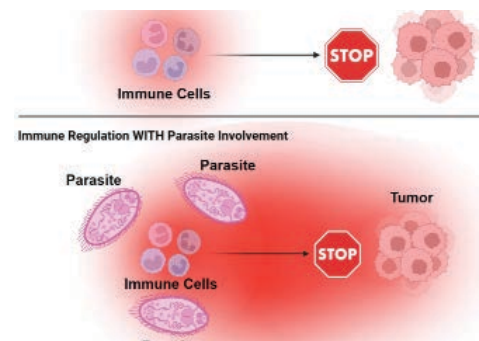


Figure 3: Parasite presence overrules tumor immune suppression. A parasitic infection leads to major inflammation that can overcome cancerous cells' efforts to stop immune system activity. The impact of promoting cytokine release by parasites further amplifies this immune activity.

Attack on Angiogenesis

Parasites also play a defensive role in immunomodulation by preventing angiogenesis. For example, in a 2023 study on the anticancerous activity of the *Toxoplasma gondii* parasite, researchers found that, in parasitically infected mice, vascular endothelial growth factor (VEGF) levels were significantly lower than those uninfected. VEGF is key for the development of blood vessels around tumors, and lowering its production creates an unideal, hypoxic environment for cancer growth.¹³ Interestingly, because angiogenesis is integral for wound repair, the immune system experiences even greater stimulation when angiogenesis is suppressed, noticing the change in necessary function.¹⁴ This further supports the offensive mechanisms by which parasites curb tumor growth as described above.

Molecular Mimicry and Cross-Immunity

Tying back to the hygiene hypothesis, another powerful anti-cancer mechanism of parasites is their ability to perform molecular mimicry and induce cross-immunity. The immune system typically identifies and distinguishes cell types with remarkable specificity, using surface molecules (antigens) on foreign cells as markers. On harmful cells, like parasites or cancer cells, antigens prompt the immune system to generate complementary antibodies against these cells. Notably, multiple researchers have found that lower specificity anti-parasitic antibodies can also bind to cancer cells, which typically evade immune system attack by presenting weak and indiscernible antigens.¹⁵ This phenomenon is known as molecular mimicry. While molecular mimicry can be detrimental when pathogens share surface proteins with healthy cells (sometimes triggering autoimmune disease), its ability to induce attacks on cancer cells is revolutionary.

Implications and Future Research Goals

While these discoveries seem game-changing for cancer therapy, it is imperative to consider the risks of using parasites as well as where research must progress in order to make this novel approach a viable treatment option.

Firstly, increasing the specificity of immune activation is key. If parasites can be identified or genetically engineered to target only cancerous cells while avoiding

healthy tissue, parasitic vaccines could surpass conventional therapies such as chemotherapy, which often inflict severe collateral damage. However, achieving this level of precision is technically challenging because cancer cells share many surface markers with healthy cells. Training the immune system to distinguish these molecular differences without triggering autoimmunity remains one of the greatest obstacles in cancer immunotherapy.

Moreover, before introducing parasitic treatments into patients, the inherent harm of parasitic infections needs to be dampened. This could be achieved through recombinant technology that reduces parasitic harm while maintaining immune boost. This may also look like transferring segments of parasite genetic material that code for cross-immunity promoting cell-markers into less harmful bacteria, inducing molecular mimicry without the harmful consequences of parasitism.

As it stands, parasitic cancer therapy is a paradox, with agents of disease aiming to be used as instruments of healing. However, if researchers are able to overcome the challenges of specificity and safety, this paradox will unravel and parasites will redefine the boundaries of cancer treatment. Ultimately, nature's most notorious antagonists could become an unexpected ally in the fight for human health.

ACKNOWLEDGEMENTS

I would like to thank Brianna Parrington and Jordy Tu, PhD students in Molecular and Cell Biology and in Infectious Diseases and Immunity, respectively, at UC Berkeley, for generously offering their time, insightful feedback, and scientific expertise in support of this article.

REFERENCES

1. Merriam-Webster. (n.d.). Parasite. In Merriam-Webster.com dictionary. <https://www.merriam-webster.com/dictionary/parasite>
2. Stiemsma, L. T., Reynolds, L. A., Turvey, S. E., & Finlay, B. B. (2015). The hygiene hypothesis: Current perspectives and future therapies. *ImmunoTargets and Therapy*, 4, 143–157. <https://doi.org/10.2147/ITT.S61528>
3. Eissa, M. M., Salem, A. E., & El Skhawy, N. (2024, October 5). Parasites revive hope for cancer therapy. *European Journal of Medical Research*, 29(1), 489. <https://doi.org/10.1186/s40001-024-02057-2>
4. Mellman, I., Coukos, G. & Dranoff, G. Cancer immunotherapy comes of age. *Nature* 480, 480–489 (2011). <https://doi.org/10.1038/nature10673>
5. Akgül, H., Tez, M., Ünal, A. E., Keşkek, M., Sayek, İ., & Özçelik, T. (2003). *Echinococcus* against cancer: Why not? *Cancer*, 98(9), 1998–1999. <https://doi.org/10.1002/cncr.11752>
6. Qin, L., Chen, C., Chen, L., Xue, R., Ou-Yang, M., Zhou, C., et al. (2017). Worldwide malaria incidence and cancer mortality are inversely associated. *Infectious Agents and Cancer*, 12(1), 1–8. <https://doi.org/10.1186/s13027-017-0117-x>
7. Bo, R., Yasen, A., Shao, Y., Zhang, W., Lin, R., Jiang, T., et al. (2020). Co-existence of hepatocellular carcinoma and cystic echinococcosis. *Infectious Agents and Cancer*, 15(1), 1–8. <https://doi.org/10.1186/s13027-020-0275-0>
8. National Cancer Institute. (n.d.). NCI dictionary of cancer terms. National Institutes of Health. <https://www.cancer.gov/publications/dictionaries/cancer-terms>
9. Cleveland Clinic. (n.d.). Cytokines. <https://my.clevelandclinic.org/health/body/24585-cytokines>
10. Yang, F., Sun, X., Shen, J., Yu, L. P., Liang, J. Y., Zheng, H. Q., et al. (2013).

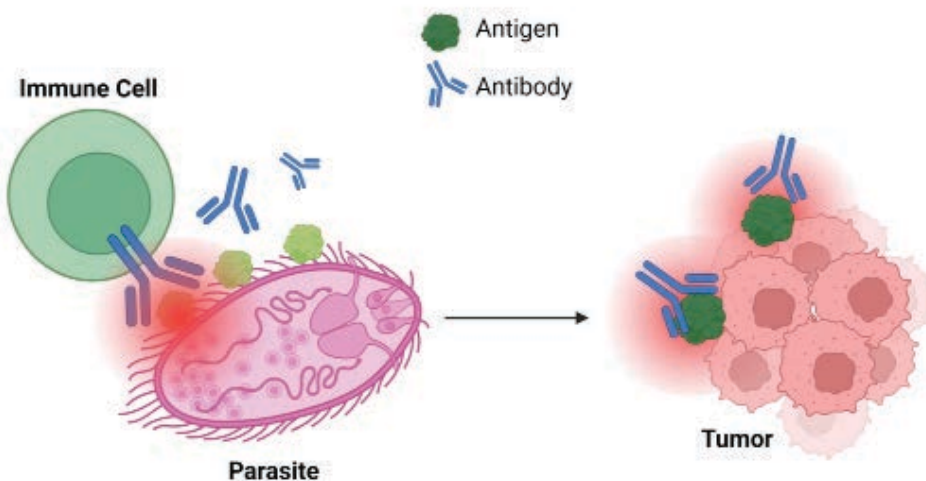


Figure 4: Mechanism of molecular mimicry. Immune cells are able to recognize surface proteins (antigens) on parasites and produce antibodies to surround and compromise the parasite (left). Some anti-parasite antibodies have low enough specificity that they can also bind to tumor antigens with similar properties (right). This creates a cross-immunity effect.

- A recombined protein (rSj16) derived from *Schistosoma japonicum* induces cell cycle arrest and apoptosis of murine myeloid leukemia cells. *Parasitology Research*, 112(3), 1261–1272. <https://doi.org/10.1007/s00436-012-3260-8>
11. Atayde, V. D., Jasiulionis, M. G., Cortez, M., & Yoshida, N. (2008). A recombinant protein based on *Trypanosoma cruzi* surface molecule Gp82 induces apoptotic cell death in melanoma cells. *Melanoma Research*, 18(3), 172–183. <https://doi.org/10.1097/cmr.0b013e3282fecaab>
 12. Shojaeian, A., Barati, N., & Motavallihaghi, S. (2023). Investigating the inhibitory effects of hydatid cyst fluid and its antigens on cancer progression: A review. *Preprints*, 1–9. <https://doi.org/10.20944/preprints202307.2141.v1>
 13. Eissa, M. M., Gaafar, M. R., Younis, L. K., Ismail, C. A., & El Skhawy, N. (2023). Prophylactic anti-neoplastic activity of *Toxoplasma gondii* RH-derived antigen against Ehrlich solid carcinoma with evidence of shared antigens by comparative immunoblotting. *Infectious Agents and Cancer*, 18(21), 1–13. <https://doi.org/10.1186/s13027-023-00500-3>
 14. Lopes-Coelho, F., Martins, F., Pereira, S. A., & Serpa, J. (2021). Anti-angiogenic therapy: Current challenges and future perspectives. *International Journal of Molecular Sciences*, 22(7), 1–26. <https://doi.org/10.3390/ijms22073765>
 15. Ubillos, L., Freire, T., Berriel, E., Chiribao, M. L., Chiale, C., Festari, M. F., et al. (2016). *Trypanosoma cruzi* extracts elicit protective immune response against chemically induced colon and mammary cancers. *International Journal of Cancer*, 138(7), 1719–1731. <https://doi.org/10.1002/ijc.29910>

IMAGE REFERENCES

1. Banner Image: National Library of Medicine. (n.d.). MedlinePlus. <https://medlineplus.gov>
2. Figure 1: Stiemsma, L. T., Reynolds, L. A., Turvey, S. E., & Finlay, B. B. (2015). The hygiene hypothesis: Current perspectives and future therapies. *ImmunoTargets and Therapy*, 4, 143–157. <https://doi.org/10.2147/ITT.S61528>
3. Figure 2, Figure 3, and Figure 4: <https://www.biorender.com>